Enhancing the Belief and Self-efficacy of Engineers for Management

An Interactive Learning Model

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Abstract

Little research considers interactive learning in engineering management. This study proposes a collaborative learning style for engineering workers facing a managerial transition. The examination features three learning opportunities: class lessons, job characteristics, and self-sustaining. A structural equation model serves to test propositions pertaining to their interactive effects based on implicit belief and self-efficacy theories, which stress how beliefs about improvement of managerial abilities mediate between the learning and capability and performance self-efficacies. Tests among 449 engineering workers from Taiwan's technical firms reveal the significance of this model. Each learning contributes separate advantage: classroom lessons most favoured performance efficacy, job characteristics most favoured improvement beliefs, and self-sustaining favoured competency efficacy the most. Ideally, a combined approach appears even better, and successful outcomes arise for those who can connect their needs with emergent learning opportunities.

Keywords

Engineering Management; Job Characteristics; Self-sustaining; Implicit Beliefs; Self-efficacy for Management

Introduction

Private-sector engineers often make transitions into management when they approach a finite technical path at which managerial positions offer higher rewards and symbols of success. These jobs tend to be project based, such that engineering managers assume almost equal technical and administrative responsibilities [1], and require to expand their capabilities to navigate social and organizational systems [2]. Outstanding firm performance is only possible when individual managers recognize what they need to improve [3], and execute courses of required actions, with the belief and self-efficacy necessary to attain the designated outcomes [4]. Knowledge of interactions between learning and these mind factors can help technical firms better train their engineers for effective managerial movements, but little research in an engineering context takes such a position.

Engineering management abilities refer to the interdisciplinary skills required in the middle engineering career stage, in which engineers shift their job skills, from reduction approaches to problem-solving toward practices of management [5]. This transition tension affects three dyadic parties: the educational institution, the employer/company, and the individual engineering worker, with each dyad connecting to one another when respective benefits are sustained [6]. A successful managerial transition in engineering thus should entail the interactive influences among the three entities. Whereas, prior studies in continuing education for engineering and other professions investigate primarily the direct association between individual learning demands and job contexts [7], [8]. Seldom does research consider interactive effects. By providing empirical evidence of such a purpose, this article aims to bridge the gap in engineering management development literature.

An implicit belief structure entails an unconscious assumption about the malleability of certain capabilities, whether fixed or learnable through training [9]. It therefore can act as a framework to connect learning activity and assessments of its outcomes, such as trainees' self-efficacy concepts and their engagement in post-assessment development opportunities [10], according to the trainees' belief in learning efficacy [8]. This study thus asks, How do learning activities provided respectively by the three entities interact to alter the self-efficacy of engineers who face a management transition, related to whether managerial capabilities can be improved.

In the subsequent sections, this article proposes an interaction of three learning opportunities: classroom lessons offered by educational institutions, job characteristics designed by the organization, and self-learned approaches given by the individual engineers. Using structural equation modeling (SEM) in a questionnaire survey, this study then determines the amount of learning engendered by the three types of learning among R&D and general engineers from technical firms in Taiwan. The learning benefits discussed herein reflect that these learning opportunities in engineering management are open to assessment in terms of self-efficacy belief structure.

Managerial Learning Opportunities and Interactions

Formal Classroom Lessons

Taking classroom lessons to gain new job skills often is the first idea for those facing a job transition [6]. It suggests learning outside the workplace, including internal courses offered by employers and external management and MBA programs offered by university or local extension schools and corporate internal job training courses [5]. With this approach, trainees can learn with a group of students with similar learning interests and without the distractions of work. Although this formal learning approach generally cannot transfer management skills to jobs immediately, when emphasizing social issues, this type of learning can enhance trainees' social capabilities because it often requires team report collaboration [11].

Self-Sustaining

Learning also depends on the individual trainees [12], which pertains particularly to trainees' self-sustenance, willingness to be criticized, and commitment to lifelong development [13]. In management education research, self-supported behaviour appears in all existing competence models, because persons who can follow this path tend to be well grounded, reflective, and self-disciplined [3]. In engineering literature, self-sustaining behaviour such as reflection and reading is essential for inspiring all types of learning, because poor self-sustained engineering managers can easily get derailed [14].

Job Characteristics

The job skills of engineers include varied characteristics, focused not just on task expertise and independence, but also human relationships [15]. Technical organizations often incorporate a taskforce structure to provide technical workers both job characteristics without a management title [1]. Greater independence comes with skill breadth, and greater influence stems from authorized responsibility and position advancement [14]. Therefore, if possessing any of these elements, engineering workers can learn and develop relevant managerial skills on the job. Accordingly, technical independence, managerial influence, and position level constitute three dimensions required for job characteristics and functions.

An Integrative Learning Approach

Although function separately, the three types of learning between each dyad is interactive in terms of performances [6]. In the educator and employer or employee dyad, for instance, the hiring company expects the educational institutions to provide substantial courses to educate squandered managers, while the institutions expect the recognition of the company for their contributions to firm performance. Meanwhile, engineers expect their companies or employers to provide substantial administrative job opportunities and increased recognition dependent on their improvement in advanced management knowledge. On the other hand, the companies guide engineers through job and responsibility designs, while engineers perceive job characteristic structures of their companies that guide them more than their own personality difference at work [16], [1]. Further, through reflection, managers are motivated to adjust their biased workplace experience to match the knowledge they learn from the educational programs. Therefore, beyond the previously predicted relationships, this research hypothesizes the interaction among the three learning pathways as the first path model in Fig. 1 displays:

Hypothesis 1: The three learning pathways—classroom lessons, self-sustaining, job characteristics— positively influence one another.

Learning Effects on Improvement Beliefs and Self-Efficacy for Management

The Malleability of Improvement Beliefs

People tend to reflect more on unsuccessful experiences and look for possible recoveries [3], such that trainees' attention falls naturally on skills and capabilities that they lack and can improve during attribute development. This lacked skill search during learning aligns with implicit belief theory, in the sense that people should have more favourable attitudes toward attribute development and believe that they can acquire missing capabilities [9], [8]. Therefore, people who believe that a particular ability is malleable and can be improved would experience higher self-efficacy in learning about it than those who believe that it is fixed and non-malleable [10]. The question is, depending on the extent of learning, can this improvability belief structure be improved?

In engineering, though the reasoning differs, career motives change, from technical interests to management, due to task environment changes [16], [1]. Roberts and Biddle [17] also argue that the superiority of good engineering managers results from not just greater follow-up skills (e.g., project monitoring, controls over task detail), but also better upfront skills, such as work facilitation, upward communication, and getting others' support [15]. These changes of career motives and improved managerial abilities of engineers in terms of task environment changes, regardless of their prior technical interests, may imply the change potential of implicit beliefs and self-efficacy for management in this transition course. In particular, genuine learning requires trainees to reflect on their task performance in relation to their daily experience within and outside the workplace. Furthermore, learning may imply the construction of an enhanced mental model [3]. When improvement occurs after some form of learning, trainees' mental beliefs and improvability concepts related to these changed skills may increase through their reflection on the actual improvements, even if the learning only entails skill training. This incremental belief shift, as a change in the motivational driver, may provoke another learning course. In turn, influence on beliefs due to learning occurs. Thus,

Hypothesis 2: The involvement of engineers in learning positively affects their improvement beliefs about managerial abilities.

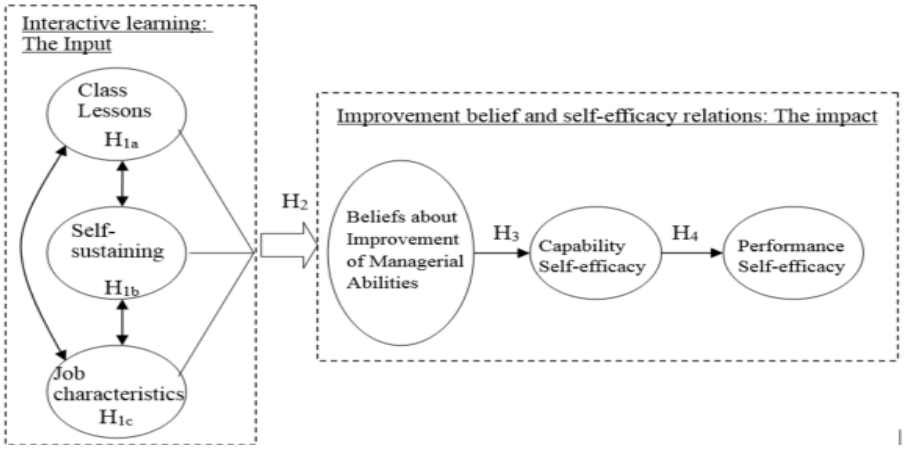


FIG. 1 THE RESEARCH FRAMEWORK

The Impacts of Improvement Beliefs on Self-Efficacy

An improvement belief is distinct from self-efficacy. Beliefs about how abilities can be changed focus more on motivation, whereas self-efficacy relates more to judgment [4]. Improvement beliefs constitute a person's general view of reality, but self-efficacy indicates his or her confidence about specific personal characteristics that might be applied to attain particular outcomes [8]. A person thus could believe that it is possible to improve capabilities but lack self-efficacy about developing those capabilities him- or herself, whether due to personal unfeasibility or a lack of necessary opportunity; they are different structures, and both should be included in learning research [8].

Self-efficacy involves not just people's ability judgment but also their confidence in applying those abilities to attain designated performance [18]. Thus, self-efficacy should comprise both capability and performance aspects, which connect to improvability beliefs: Improbability beliefs refer to trainees' motivation about which efficacies

develop, and self-efficacy implies that the capability dimension comes before the performance dimension in terms of its influence on learning outcomes. Although highly correlated, these three attributes represent separate constructs, with improvability beliefs acting as a mediator to connect learning opportunities and competence self-efficacy, and then finally performance self-efficacy, as the second path model in FIG. 1 shows.

Hypothesis 3: The improvement beliefs of engineers about managerial abilities positively affects their capability self-efficacy.

Hypothesis 4: The capability self-efficacy of engineers further positively affects their performance self-efficacy.

Research Method

The Measuring Instrument

A questionnaire constructs the two path models in FIG. 1. This questionnaire contains six sets of self-report scales: the three learning pathways, and improvement beliefs and competence and performance self-efficacies for management. Self-report measuring approach is appropriate for studies concerning private events [19]. To mitigate common method bias that often occurs in self-report instruments, this study applies semantic differential and different response formats to separate the measurements of the predictor and criterion variables [20]. Confirmatory Factor Analyses (CFA) further confirmed separately the discriminant and convergent validity of these six scales: Their GFI, AGFI, and CFI were all larger than 0.90, and loadings of the first level factors were all significant at $p<0.001$ level. Corresponding CFA models with common variance factor also indicated that they included no common method biases. This section briefly describes the contents of these six measurements. Their detailed contents and Cronbach's alphas of these measures appear in TABLE 1.

1) The Three Learning Pathways

Classroom lessons. This measure gauges the amount of training outside the workplace, including corporate internal classes and external programs offered by educational institution. Internal classes focus on only managerial lessons. The response options range from (0) never adopt, to (6) definitely adopt, preceded by asking the respondents to review their adoption frequency for each of the activities to improve their work skills and knowledge (these options applied to the following self-sustaining measurement scale as well).

Self-sustaining. This measure gauges the amount of self-provided learning activities in which an engineer may engage, including self-reflection, book and journal reading, and participation in professional association and seminars [14].

Job characteristics. This measure gauges three job dimensions: task independence, influence and responsibility, and position level [14], including items such as if working under supervision (reverse statements), or own right to make decisions that influence the company (see TABLE 1 for details). The scale ranges from (1) totally disagree to (7) totally agree, preceded by asking the respondents to assess each statement based on their current work status. Position level is a self-report measure ranging from (0) not a manager to low-, middle-, or (3) high-level manager.

2) Improvement Beliefs about Managerial Abilities

This construct pertains to respondents' implicit faith about the improvability of multiple job skill profiles, including knowledge, abilities, skills, and other characteristics for management development. It includes 15 skills and attributes typical of engineering managers, derived from the 48 items listed by Maurer et al. [8]. The response options range from (0) it cannot be improved to (6) it can be totally improved. Prior to the questions, a statement about whether managerial abilities can be improved through training and years of working appears to remind the respondents to rate based on their personal experience.

3) Capability and Performance Self-Efficacies

Capability self-efficacy. This construct pertains to personal judgments about if a manager engages the three types of capabilities at work: technical know-how, interpersonal skills, and self-regulating skills. The measurement comprises a profile of 10 job capabilities pertinent to these dimensions, modified from the 57 managerial self-

efficacy items suggested by Robertson and Sadri [21]. In line with existing self-efficacy scales [22], prior to the rating, respondents were asked to compare their confidence with those in the same position about whether they could do better when having their very best effort. The response options range from (0) disagree to (6) absolutely agree with the statement. This option applies to the following performance self-efficacy scale as well.

Performance self-efficacy. This construct pertains to managers' judgment about whether they are capable, in terms of task and relationship, to accomplish a job assigned by the organization. The measurement comprises six items adopted from Robertson and Sadri [21], preceded by a statement that asks the respondents to rate their confidence by considering themselves as a manager with subordinates working under and if they can perform better than those in the same position when doing their very best effort.

Sample

In an empirical survey, the authors first contacted the personnel and public relations managers in ten high-tech private firms in Taiwan to inquire about their willingness to participate. Six companies finally agreed to participate. These firms produce telecommunication research, rare materials, integrated circuit design, liquid crystal displays, computers and peripherals, and stainless steel goods, and all are involved with R&D to some extent. Because it was difficult to collect data using a stratified sampling method with this largely involved population, different numbers of questionnaires were sent to the firms, according to their instructions. The questionnaire provided descriptions of the purpose of the research and assured participants' confidentiality, as well as a postage-paid envelope to return the questionnaire directly to the authors.

In total, of the 800 questionnaires provided, 534 were returned, among which 32 were incomplete and 53 were from non-engineering workers. A total of 449 subjects therefore remained for the analysis. Persons responding later are assumed to be more similar to non-respondents. An early to late test, which compared the demographics and the primary research variable means of the first 75% respondents to those of the late 25% respondents, reveals that there is no significant statistical difference between those who returned the questionnaires earlier and later, suggesting that there is no significant non-response bias in this sample.

In the sample, approximately 82% of the respondents were men; their ages ranged mostly between 25 and 40 years with an average of 36 years; and they all had college degrees or more education. They had worked an average of 10 years but had been with their current employers for an average of 5.2 years, which might reflect the high job mobility of young engineers before the age of 30 years. Moreover, they all hold a job title of engineer, with 40.5% calling themselves R&D engineers (N = 182) and 59.5% general engineers (N = 267), across the fields of systems, sales, operations, and others. As for the position level, 74.4% self-classified as non-managers, 14.7% low-level managers, 10.2% middle-level managers, and 0.7% higher-level managers.

Correlation analyses reveal that technical and R&D engineers correlate negatively with age, job tenure and positional level, but positively with gender (female) and education. In contrast, the self-rated position level, from low to high, correlates positively with age and tenure but negatively with technical and R&D position, and it has no correlation with education level. Overall, these demographic data indicate that young engineers, including R&D staff, engage in little management or administrative work (also see TABLE I). Although this sample ranges in ages from 25 to 40 years, 25.6% of the older respondents undertake managerial work. This characteristic of the sample supports an investigation of engineers facing managerial transitions.

Data Analysis

Structural equation modelling (SEM) using the average factor scores provided a means to solve the path models after confirming the factor structures by CFAs. For clarifying the interactions among the variables, the test started by treating the three types of learning as three independent, uncorrected exogenous learning sources, with a path to the belief and both self-efficacy structures following the hypothesized direction. Modification index (MI) and path coefficients, then adjusted the model as necessary [23]. According to this adjusting procedure, six SEM analyses were processed before confirming the final structure that had the best model fit shown in FIG. 2.

Results

Reliability and Validity of the Measuring Instruments

TABLE 1 illustrates separately the reliability, and the discriminant and convergent validities of the two path models given in FIG. 2 respectively: GFI = 0.93, AGFI = 0.90, CFI = 0.96, Chi-square = 286.66, df = 111 for the interactive learning model, and GFI = 0.90, AGFI = 0.88, CFI = 0.97, Chi-square = 753.35, df = 420 for the improvability belief and self-efficacy relationship model. TABLE 1 also shows that all sixteen sub-factors satisfy Cronbach's alpha reliability criteria and align with the designated constructs and contents.

TABLE 1 RELIABILITY AND VALIDITY CHECKS AND CONTENTS OF THE MEASUREMENTS

Contents	CFA loading	Cronbach Alpha
Learning Paths		
Class lessons:		
1. Educational institutions:	.61	0.86
Short-term programs	.90	
Long-term programs	.85	
2. Corporate programs:	.74	0.91
Self management courses.	.82	
General management courses.	.96	
Upper level management courses.	.90	
Organizational culture and orientation.	.69	
Self-sustaining:		
1. Reading:	.89	0.90
Job-related articles or journals	.75	
Professional books	.89	
2. Professional organization participate:	.80	0.80
Join professional societies.	.95	
Attend professional seminars	.86	
3. Reflection and self-learning	.49	--
Task functions:		
1. Empowerment	.60	0.90
Make decisions that influence the company.	.89	
Initiate activities for the company.	.93	
Represent company to talk important issues.	.81	
2. Task independence	.15	0.61
Have to work under supervision, direction (R).	.74	
Require permissions to use of resources (R).	.59	
3. Managerial position level	.51	--

Contents	CFA loading	Cronbach Alpha
Improvability Belief:		
1. Work expertise:	.67	0.90
Company specific expertise.	.87	
Position specific expertise	.94	
Expertise diversity	.81	
2. Self-awareness:	.78	0.89
Self-learning orientation	.96	
Improving awareness	.94	
Loyalty	.70	
3. Directing others:	.86	0.93
Supervise, direct subordinates	.92	
Coordinate to get job done	.95	
4. Interpersonal:	.81	0.92
Interpersonal relation	.88	
Work relationship	.92	
Teamwork and partnership	.88	
5. Entrepreneurial:	.80	0.93
Influence	.90	
Leadership	.92	
Creativity	.81	
Visionary thinking	.80	
Capability self-efficacy:		
1. Self-regulating	.87	0.86
Can plan and execute accordingly.	.91	
Use time effectively.	.86	
Work hard all the time.	.70	
2. Interpersonal capable:	.83	0.87
Can advise others clearly and with tact.	.91	
Can speak clearly in an organized way	.80	
Can convey understanding to others.	.80	
3. Task know-how:	.88	0.94
Logical analysis and decision	.86	
Deal issues in proper details	.90	
Asses information objectively	.92	
Ask pertinent questions	.90	
Performance self-efficacy:		
1. People-based:	.92	0.87
Direct by subordinates' strength/weakness	.84	
Orientate new employees	.83	
Work schedule for subordinates	.83	
2. Task-based:	.88	0.93
Plans for new job assignment	.87	
Supervise the unit to prepare job execution	.95	
Set goals and directions for the unit	.91	

a. All loadings are significant at $p<0.001$, except Task function→Task independence ($p = 0.194$).
b. Model fitting: Learning paths: GFI = 0.93, AGFI = 0.90, CFI = 0.96, Chi-square = 286.66, df = 111; improvability beliefs and the two self-efficacies: GFI = 0.90, AGFI = 0.88, CFI = 0.97, Chi-square = 753.35, df = 420.

Correlations between Learning and the Efficacious Effects

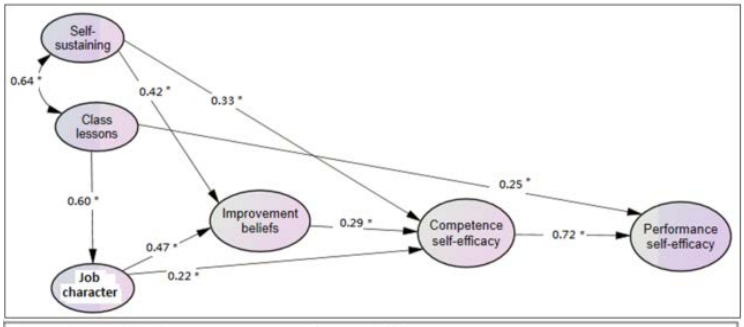
TABLE 2 reveals descriptive means and correlations among the learning opportunities and their effects on increasing improvement beliefs and self-efficacies, with the effects of firm difference, position status, and personal gender and education level controlled because these variables may disturb the relationships of interest. The descriptive means show that the belief and self-efficacy subscales all have an average between 3.75 and 4.28, around the seven-point medium. They also highlight that corporate training program is more popular than school

educations, and the self-sustained approaches, including reflection, reading and professional association engaging, are within a median use frequency range. Further, the three job characteristics subscales have a relatively low score, supporting that these respondents are mostly mid-aged engineers facing managerial transition. Most of the correlations are significant and positive, except those with task independence, which may imply a lesser contribution in this dimension in the impact. Overall, these significant correlations support our first hypothesis, in that the three types of learning relate positively to both competence and performance self-efficacies.

TABLE 2. CORRELATIONS [A.] AMONG THE SUBSCALES OF LEARNING AND THE BELIEF AND SELF-EFFICACY CONSTRUCTS

		Improvability Beliefs					Competence self-efficacy			Performance self-efficacy	
		Job expertise	Self-awareness	Inter-personal	Directing	Entrepreneur	Self-regulating	Inter-person relation	Task knowhow	People	Task
	Mean	4.11	4.00	4.03	4.02	3.75	4.28	4.03	3.90	4.11	4.10
Class lessons:											
Educational institutions [b.]	3.04	.20*	.26*	.21*	.26*	.27*	.20*	.12*	.16*	.27*	.24*
Corporate programs [b.]	3.69	.35*	.38*	.41*	.40*	.43*	.38*	.32*	.35*	.44*	.44*
Self-sustaining:											
Reading [b.]	4.14	.38*	.31*	.35*	.33*	.29*	.38*	.31*	.40*	.37*	.42*
Prof association engage [b.]	3.90	.31*	.26*	.24*	.25*	.26*	.27*	.20*	.28*	.29*	.36*
Reflection [b.]	4.04	.34*	.31*	.34*	.37*	.35*	.33*	.30*	.35*	.35*	.33*
Job characteristics:											
Influence [b.]	2.72	.07	.23*	.20*	.26*	.28*	.16*	.12**	.28*	.14*	.14*
Task independence [b.]	2.60	.07	-.09	-.07	-.02	-.05	-.08	.02	-.05	.01	.04
Manager position level [c.]	0.37	.10*	.17*	.17*	.22*	.18*	.19*	.19*	.24*	.18*	.23*

a. The effects of gender, education, and firm are controlled
b. Class lessons, self-sustaining: 7-point frequency scale (0-6); task function: 7- point disagreement/agreement scale (1-7).
c. Coding: 0: non-manager, 1: low, 2: medium, 3: high level manager.
*$p < .05$



Total effects of each learning on the belief and efficacy structure:

From / To	Self-sustaining	Class lessons	Job characteristics
Improvement beliefs	0.423	0.279	0.467
Competence self-efficacy	0.448	0.213	0.356
Performance self-efficacy	0.321	0.401	0.256

FIG. 2. RESULTS OF SEM AND TOTAL EFFECTS GIVEN BY THE THREE LEARNING PATHWAYS ON THE BELIEF AND SELF-EFFICACY CONSTRUCTS

The Path Model

FIG. 2, in which the six latent constructs comprised respectively the eighteen subscales in TABLE 2, illustrates the results of the structural paths as well as the total effects given by the three types of learning on the belief and self-efficacy constructs. The model indicates satisfactory fit: GFI = 0.92, AGFI = 0.90, CFI = 0.94, NFI=0.91, RMS=0.064, Chi-square = 329.9, and df=126. It also shows a significant effect path starting from self-sustaining, that is, self-sustaining<→(0.64) class lessons→(0.60) job characteristics→(0.47) improvability belief→(0.29) competence self-efficacy→(0.72) performance self-efficacy. There are also following significant direct impacts: Class lessons→(0.25) performance self-efficacy; task function→(0.22) competence self-efficacy; self- sustaining→(0.42) improvement belief; self-sustaining→(0.33) competence self-efficacy. Thus, the second hypothesis, in that improvement belief serves as a mediator between learning and efficacious behaviour, receives support.

The total effects below the figure instead show that improvement beliefs receive most effect from task functions

(0.467), followed by self-sustaining (0.423), and finally classroom lessons (0.279); competence self-efficacy receives most effect from self-sustaining (0.448), then task functions (0.356), and finally class lesson (0.213); performance self-efficacy receives most effect from class lessons (0.401), then self-sustaining (0.321), and finally task functions (0.256). Therefore, self-sustaining appears to provide most effects, followed by task functions, and lastly class lessons, though the overall contributions are nearly trisected.

Discussion

Facilitating engineers' efforts to become competent managers is a pertinent goal for any country. This study contributes to better understand about how three pathways for management development combine to create impacts on engineering workers facing a managerial transition. The findings have several key theoretical contributions and implications.

The Separate Role of each Learning

Engineering management development requires efforts from three entities: the classroom, the job, and the individua. As found, each learning approach heightened separate advantage: classroom lessons most favoured performance efficacy, job characteristics most favoured improvement beliefs, and self-sustaining favoured competency efficacy the most. We therefore may conclude that in learning, efficacy beliefs can be enhanced by the three pathways. In line with the findings, we can also draw their separate roles in developing engineering management: The employer designates job characteristics, and the educator provides the required knowledge, associated with the workplace skills and characteristics needed; in return, the individual engineers practice the facilitated job characteristics and new knowledge at work. Individual's self-provided approaches, such as reflection, reading and participation in professional association, definitely require to initiate the process.

The Interactive Effects among the Learning

Though contribute separately, the three pathways should be combined into a collaborative mode, but rather separately. In particular, the current study found that self-sustaining marks the start of the path, because it provides the most benefit and initiates the action of classroom lessons. Next, engineers who are responsible for management tasks should incorporate with job characteristics to develop better management, because those who take advantage of this employer-provided opportunity appear to have higher efficacious beliefs. As young engineers who have not yet had a chance to learn management in the workplace, they should instead adopt a self-sustaining style, assisted by formal classroom lessons and participating in professional seminars outside the workplace, to increase their understanding of the practical workplace functions that might arise in the managerial careers they desire.

Theoretical Contributions

Though there exist sufficient opportunities to learn lacked job skills, the causal structure of self-efficacy in learning and whether learning can improve this structure remains puzzled [24]. By arguing that belief differentiates from and precedes self-efficacy, this study proposes a framework to specify the relationships between learning entities and an improvement belief—self-efficacy relationship model in engineering management. The results revealed significance of this proposed model, which support the hypotheses that interactive learning increases both competence and performance self-efficacy, mediated by improvement beliefs. These consequences consent the basic causal theory that a change of engineers' efficacious behaviour for management is concerned with whether their beliefs about management can be changed [18].

In a broad perspective, these findings concur the viewpoint that the success of engineering management accredits to those who are self-aware, reflect, and pursue for mental understanding instead of simply understanding the skills [3]. Specifically, because of the improvement belief mediator, we observe that there exists an integrative learning path, starting with an inter-influence between self-sustaining and classroom lessons, then integrating with job characteristics in the workplace to give further joint impacts. Whereas, the impacts of class lessons in this interaction appears to be indirect, which appears needed to mingle with both self-sustaining and job characteristics to achieve a hand-on, demonstrable practice in this interaction. Namely, without practical on-the-job learning,

classroom knowledge may remain theoretical.

Managerial Implication

Educators and employers need to recognize the importance of job design, which allows employees practice their skills and earn belief and task self-efficacy. The current tests indicate that work independence may be less essential as influence or empowerment in helping engineering workers moving into management. Self-efficacy is task-specific, tailored to the characteristics of work contexts [4]. This lesser relation may stress the imperative of apposite job design, because job contexts represent the amount of opportunities for learning on the job about the required skills. Therefore, in support, the employers can consider empowering engineers by incorporate administrative activities in technical ladders as a management development tool, or supplement personal efforts with internal training courses or tuition support.

As for the educational institutions, dialogues with practicing workers and tailoring classes in accordance with their job needs are requisites. Through these dialogues, educators should be reflexive about the cultural asymmetry and adaption difficulties embedded in their management pedagogy. For instance, Asian students may be less open-minded and more power-distant in relation to their teachers than their counterparts in the West, thus simply immigrating Western or advanced education model may be not the best way even in the technological arena that usually has common scientific language worldwide.

Conclusion

Movement from engineers to engineering managers may be more complicated than similar shifts in other professionals, because engineers must avoid technical obsolescence while take on new managerial duties. This study demonstrates that the amount of this learning opportunity is open to assessment, and the best learning occurs when people self-inspire and grab an emergent opportunity. However, this demonstration also relies on proper measurements that reflect personal learning experience and efficacy belief structure. Further, the current sample size limit and task characteristic design also imply that this study cannot confirm whether the benefits are universal or apply to other professionals. The current sample features technical firms with technical and general engineers, but the career paths of other engineers may differ. For example, in many Western technological organizations, good engineers can choose to stay in technical careers with the same level of reward as those in managerial careers. Additional research should track engineers at specific management levels or with different organizational backgrounds.

In addition, engineering in Taiwan, whence the current sample was drawn, is relatively less innovative than in other cultures [14]. Their job and career perspectives may differ from their counterparts in a research industry that highly values intellectual assets. Whether the results are due to the idiosyncrasies of this sample or represent a generalized phenomenon in other industries and countries remains to be confirmed. Finally, this study uses a general purpose survey approach, which may ignore the influences of contingent factors. A case study approach or longitudinal analysis might be useful in achieving such a research purpose.

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